Space Weather Technical Forecast

Issued on Monday 3 February 2025 at 12:26 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Solar winds easing. Further M-class flares expected, slight chance of an X-class flare.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Moderate over the last 24 hours with frequent M-class flares, the largest an M8.8 peaking at 03/0358UTC from AR3981.

There are now up to eight active regions on the Earth-facing disc. The majority of the activity is from the broad cluster of sunspots which are beginning to cross the central disc from the northeast quadrant, and consist of AR3976, AR3977, AR3978, AR3981 and AR3982. These form a rather large and complex area of multiple bipolar active regions, with signs of magnetic interaction between the regions suggesting the ongoing potential for notable flares. AR3976 and AR3978 continue to slowly evolve but remain Beta-Gamma magnetic types. AR3977 has recently seen some further small spots emerge in the lead portion, and gave an M5.1 flare on 02 Feb. AR3981 continues to exhibit sustained growth, especially in the intermediate and trailer portions, with at least two delta configurations evident. This region has produced the majority of the Moderate flares through the period, including the largest, an M8.8 on 03 Feb. AR3982 located to the north of AR3978, has shown steady decay in recent hours. The remaining spots groups are small and magnetically simple, with either limited evolution or slow decay.

An M4.1 flare from AR3981 at 02/2324 UTC was followed by a faint CME (coronal mass ejection) from the southeast in imagery. Analysis is ongoing to determine whether an Earth-directed component is likely. No other Earth directed CMEs were observed in available imagery.

Solar Wind / Geomagnetic Activity: Solar winds as measured by ACE at L1 showed a declining connection to CH11/+, with speeds initially near 600 km/s falling to around 450 km/s. Density was average to below average. The Interplanetary Magnetic Field, Bt, was initially weak but increased to moderate levels after 02/1600 UTC. The north-south component, Bz, was initially weakly variable before becoming predominantly moderately positive, varying over the whole period between +11/-7nT. Phi angle was positive (away from the Sun) until 02/1600 UTC, becoming negative (towards the Sun) or neutral for a time, before returning to positive. Geomagnetic activity was Unsettled to Active (Kp 3-4) at first before decreasing to Quiet (Kp 0-2), after 02/2100UTC.

Energetic Particles / Solar Radiation: High energy proton flux at GOES18 was at background levels. High energy electron flux (greater than 2MeV) at GOES16 reached High levels, peaking at

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1650 pfu. The associated 24-hour fluence persisted below the Active threshold, recording 1.29e7 integrated pfu at 03/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Generally Moderate activity is expected, with M-class flares expected at times and a slight chance of isolated X-class flares, primarily from the regions on the northeast disc.

Solar Wind / Geomagnetic Activity: There is one CME in the forecast which could give a glance early on Day 1 (03 Feb), however this is later than initially forecast and may well have missed Earth already, or perhaps passed as a weak feature.

Earth is still connected to CH11/+, but with wind speeds continuing to decline, currently around 450km/s. Solar winds are expected to continue easing through Days 1-2 (03-04 Feb), returning to generally slightly elevated or background levels by Days 3-4 (05-06 Feb).

Generally Quiet to Unsettled (Kp 1-3) geomagnetic activity is expected as Earth continues to come out of the coronal hole high speed stream, with a chance of Active (Kp 4) intervals on Day 1 (03 Feb). A decreasing slight chance of G1/Minor Storm (Kp 5) intervals remains if any CME glance is observed early on Day 1. Activity then expected to ease further from Day 2 (04 Feb) onwards, becoming generally Quiet (Kp 1-2).

Energetic Particles / Solar Radiation: GOES18 high energy proton flux is likely to be at background levels, but with a slightly increasing potential of responding to any notable flares as the sunspot regions in the northeast move into the western hemisphere. GOES16 high energy electron flux is likely to remain at Moderate to High levels through the period. The corresponding 24 hour fluence is expected to persist below the Active threshold Day 1 (03 Feb), but with an expected rising trend Days 2-4 (04-06 Feb), bringing an increasing chance of reaching the Active threshold by the end of the period.

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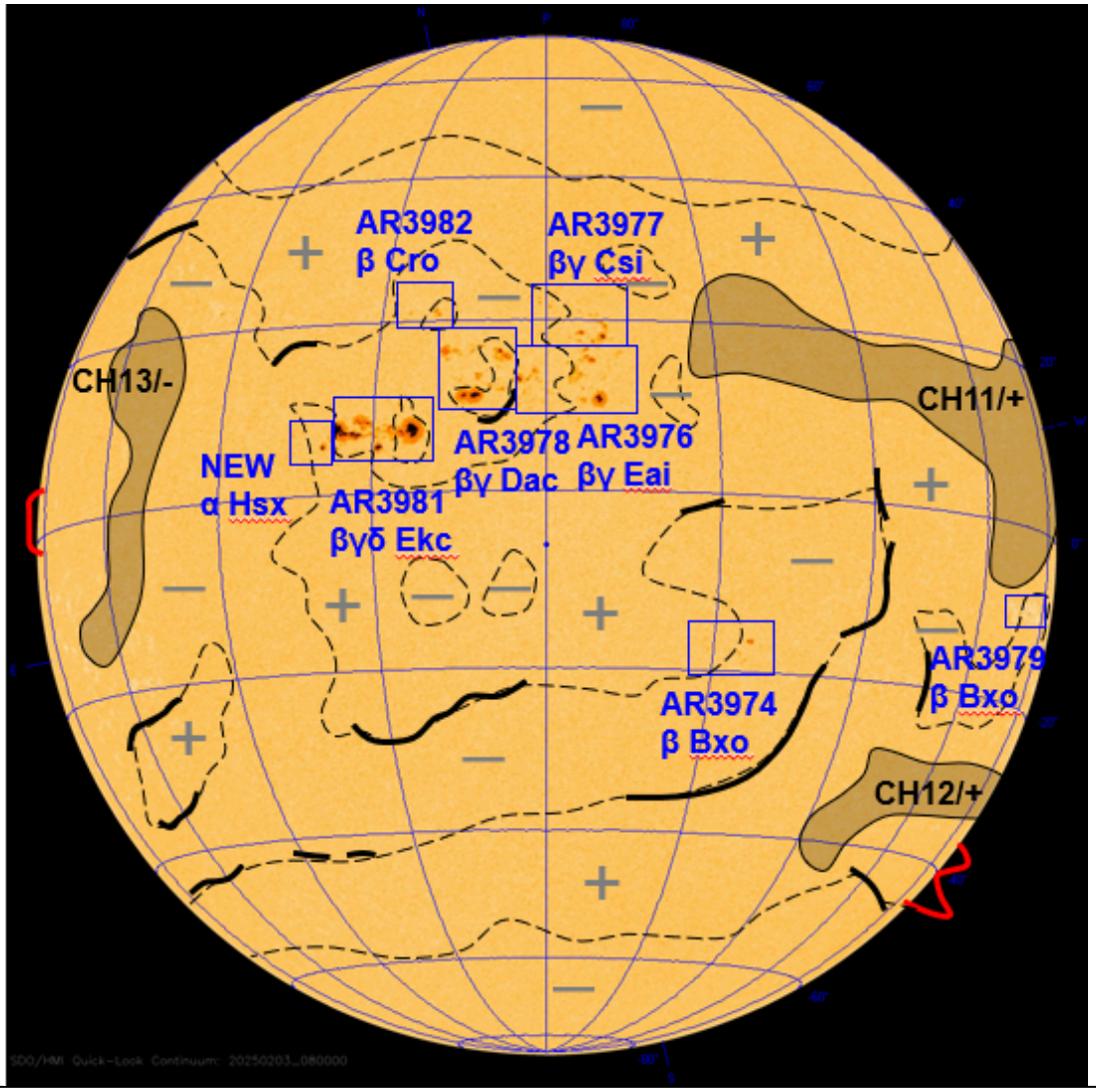
Figure 1: Solar Synoptic Map valid 03/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

One CME currently features in the forecast, however confidence is now very low. This was from a multi-stage filament eruption off the southeast disc around 30/1400 UTC. This has been modelled as passing mostly behind and south of Earth, however an arrival was forecast on 02 Feb. No definite arrival has yet been observed, with a miss or a very transient arrival most probable, although solar wind data hints at a possible weak transient from around 02/1600UTC. If any arrival does occur, it would probably just be a glancing blow with little significant effect. However, if we do see some of the main bulk of the CME, it could give a more significant geomagnetic response due to the potential high density from its filament origin. The potential for further CMEs also remains elevated, with a number of large filaments in potentially geoeffective positions and the large cluster of the sunspots in the northeast continuing to rotate across the disc. Also, faint CME from the southeast around midnight UTC, following an M4 flare from AR3981, is being analysed for any potential Earth directed component.

Earth is still connected to CH11/+ but with wind speeds continuing to be decline, currently around 450km/s. Solar wind speeds are expected to gradually ease during Days 1 and 2 (03-04 Feb), returning to generally slightly elevated to background levels by Days 3-4 (05-06 Feb). This timeframe supported by current MOSWOC ENLIL output, which is providing reasonable guidance at present, albeit slightly too high with current wind speeds.

Generally Quiet to Unsettled (Kp 1-3) geomagnetic activity is expected as Earth continues to come out of the coronal hole high speed stream, with a chance of Active (Kp 4) intervals on Day 1 (03 Feb). A decreasing slight chance of G1/Minor Storm (Kp 5) intervals remains if any CME glance is observed early on Day 1. Activity is then expected to ease further from Day 2 (04 Feb) onwards, becoming generally Quiet (Kp 1-2).

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	15	5	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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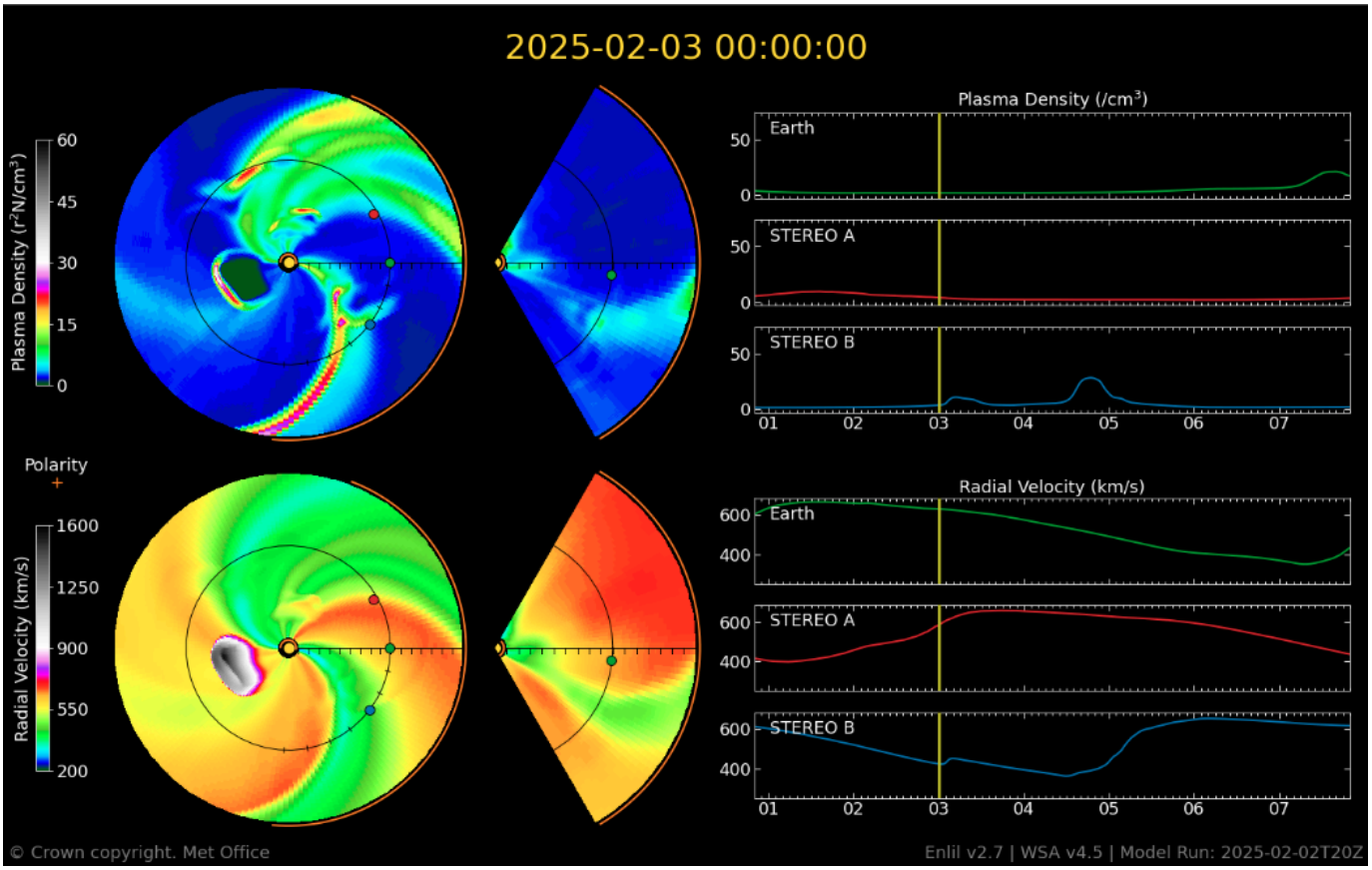
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
30/2345	Partial	Filament	29E 27S	570	02/1200 +/ 10hrs	Low confidence, possible glancing impact. - This may have arrived around 02/1600UTC as a weak feature, although this is not certain.

Figure 2: MOSWOC Enlil, showing the general declining trend in fast winds.



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Radio Blackouts - X-Ray Flares

Solar activity was Moderate over the last 24 hours with frequent M-class flares, the largest an M8.8 peaking at 03/0358UTC from AR3981.

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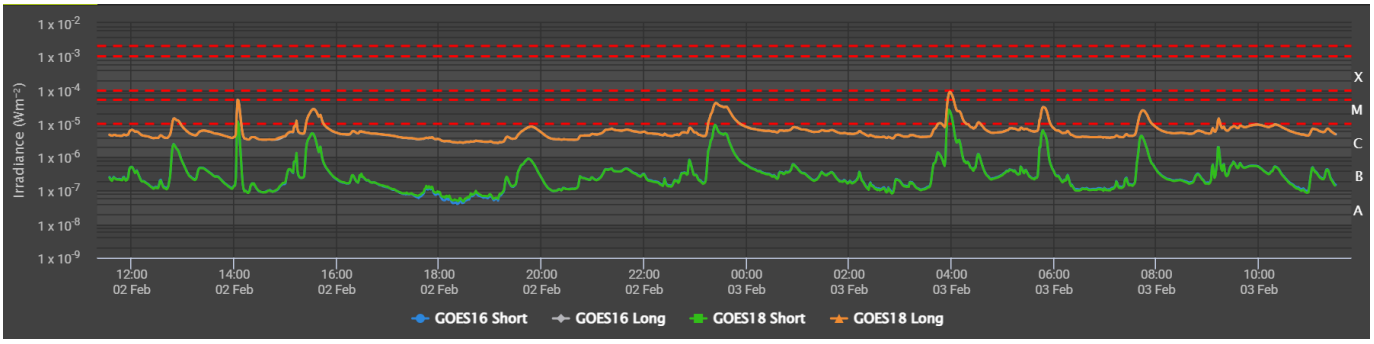
No significant regions are due to rotate off the disc in the forecast period. Recurrence suggests the potential for returning regions during the period, although far-side helioseismic output has no strong signals in the short term. Overall further M-class flares are expected, with the risk maintained throughout the period pending further developments. There is a slight chance of an isolated X-class flare from the cluster in the northeast given its overall size and complexity.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	80	80	80	80
Very Active	R3-R5 (X Class)	No	20	20	20	20

Figure 3: GOES-16 & -18 X-ray flux showing multiple M-flares, all from the cluster of sunspot regions in the northeast of the disc, and the majority from AR3981.



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Solar Radiation Storms (High Energy Protons)

Proton flux as observed by GOES-18 is currently at background levels, and is generally likely to remain that way, at least at first, with the majority of the current solar activity in the eastern hemisphere. As the large cluster of sunspots in the northeast move more into centre-disc, and then into the western hemisphere, there is a gradually increasing chance of proton flux rising in response to any notable flares.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	20	20	25
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 saw a diurnal peak to High levels on 02 Feb as the fast winds from CH11/+ slowly subside, which suggest the Van Allen belts are starting to expand outwards again following a period of being compressed and charged at a lower orbit. As solar wind speeds are expected to ease further through Days 1-2 (03-04 Feb), the Van Allen belts should continue to expand back towards GEO, bringing an increase in flux. Electron flux could continue to be at Moderate to High levels through the period.

The corresponding 24 hour fluence is expected to persist below the Active threshold Day 1 (03 Feb), but with an expected rising trend Days 2-4 (04-06 Feb), bringing an increasing chance of reaching the Active threshold by the end of the period, in the absence of further CME activity. MOSWOC REFM output is currently thought to be providing reasonable guidance, although confidence is reduced due to uncertain CME impacts.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	10	30	50	50
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

Figure 4: GOES-16 Electron flux

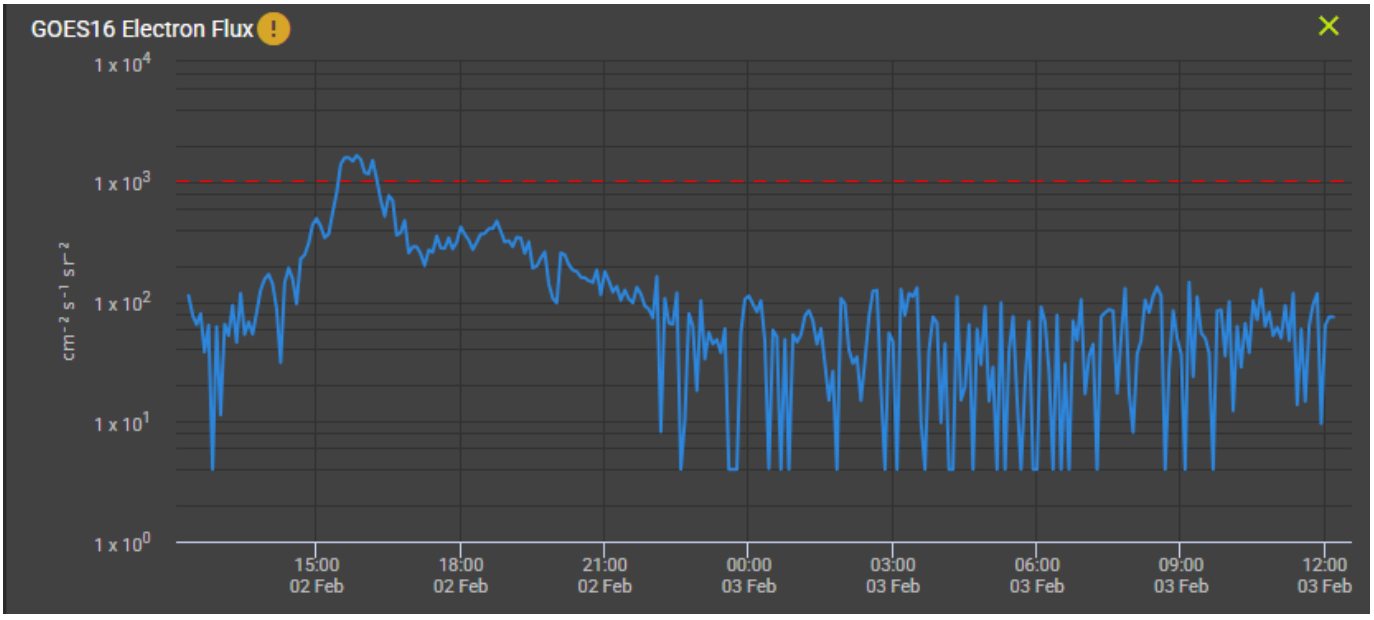

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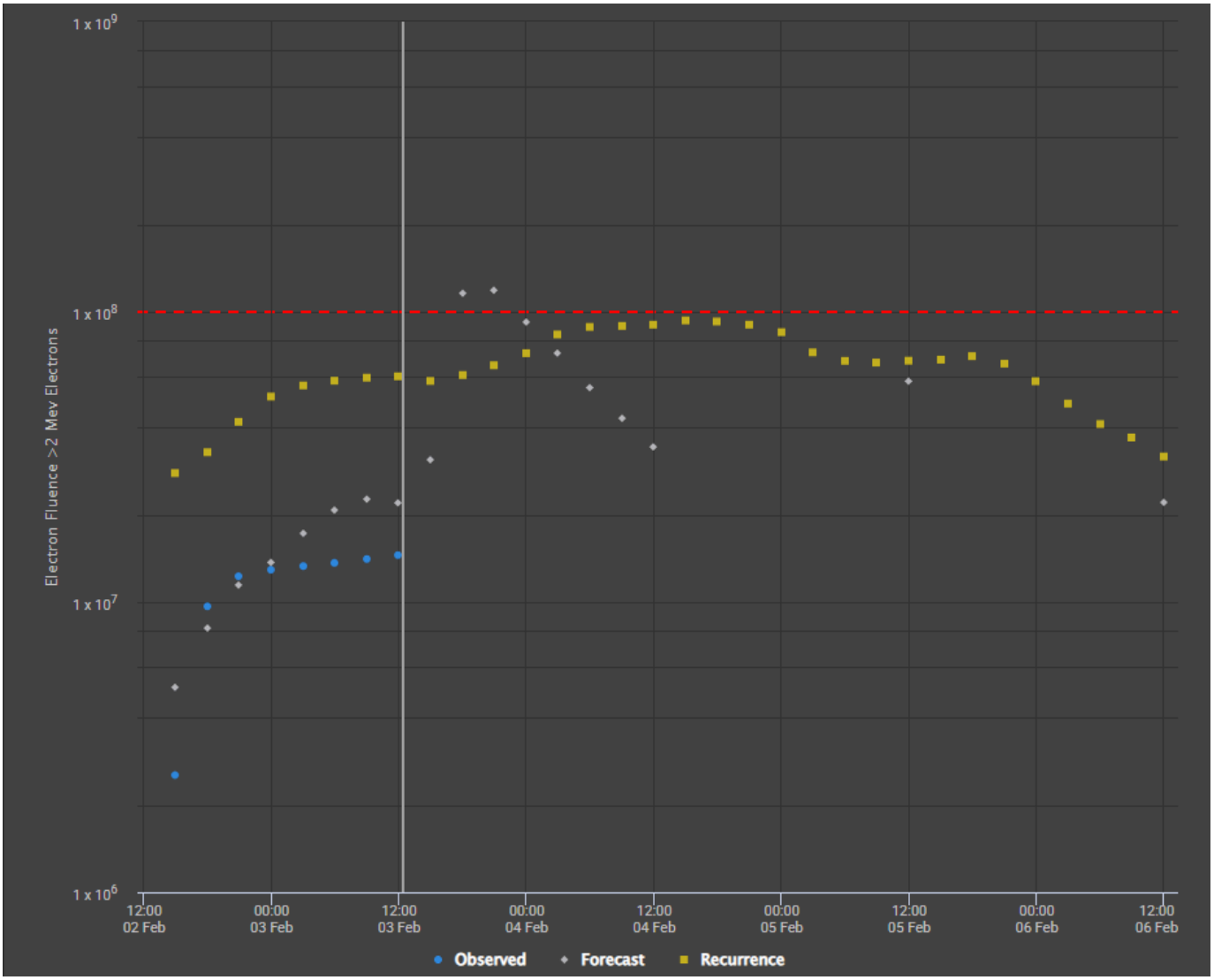
Figure 5: MOSWOC REFM, providing reasonable guidance.



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